

BLADDER WITH HIGH PRESSURE REPLENISHMENT RESERVOIR

BACKGROUND OF THE INVENTION

Field Of The Invention

The present invention relates to an improved cushioning member for an article of footwear, and more particularly to a fluid filled bladder having multiple, fluid containing chambers of differing pressures including at least one reservoir chamber for maintaining predetermined pressure levels within the bladder.

Description of Background Art

Footwear includes two main portions, an upper and a sole unit. The upper is designed to comfortably enclose at least a portion of the foot. The sole unit typically includes a midsole for absorbing the harmful impact forces created during a foot strike in order to prevent injury to the wearer. The sole unit also includes an outsole for providing traction. Some midsoles include a plurality of layers of different, resilient cushioning materials. However, over time, these midsoles break down and lose their ability to effectively cushion against the jarring forces that result from a foot strike, particularly midsoles using foam materials, such as polyurethane foam or ethyl vinyl acetate (EVA) foam. Breakdown of the cushioning material can be accelerated when the midsole is exposed to repeated heavy loads during use.

Other conventional midsoles include layers of cushioning materials combined with at least one resilient cushioning element for increased and longer lasting cushioning. One type of known cushioning element contains a cushioning fluid or gel and is commonly referred to as a

bladder. However, the bladder containing midsoles can also experience cushioning breakdown. Compared to the well known, resilient midsole materials, it takes longer for the shock absorbing properties of a gas containing bladder to diminish. For example, diffusion can cause a gas containing bladder to lose pressure over time. This loss of cushioning is magnified when a heavy load is applied or when the footwear is used over an extended period of time. While recent developments in materials have improved gas filled bladders, problems still exist with their durability and the effective life span.

Some bladders rely on "diffusion pumping" to increase or maintain a level of pressure and cushioning within their barrier walls. Diffusion pumping is discussed in U.S. Patent No. 4,340,626 to Rudy which is hereby incorporated by reference. Diffusion pumping can occur when the gas used for inflating an elastomeric, pneumatic bladder is different from the ambient air surrounding the bladder, or it is at least partly different from the ambient air surrounding the bladder. The inflating gas, such as a large molecule "supergas," discussed below, exhibits very low permeability and an inability to diffuse readily through the elastomeric barrier walls of the bladder. As a result, the pressure within the bladder increases when it is surrounded by ambient air. This is due to the nitrogen, oxygen and argon from the ambient air diffusing through the barrier material into its interior while the supergas remains within the bladder, thereby increasing the pressure within the bladder. The inward diffusion continues until the partial pressure of air in the enclosure equals the atmospheric pressure outside the enclosure. The resulting total pressure within the enclosure is the sum of the partial pressure of the diffused air within the enclosure combined and the pressure of the initial supergas.

Relying on diffusion pumping from only the outside environment is not a very accurate way to re-establish or maintain a predetermined level of pressure within a bladder. Inward diffusion from an uncontrolled environment does not allow for an accurate control of the inflation rate and the final internal pressure. Moreover, diffusion pumping will occur when it is not needed. Whether it is desired or not, diffusion pumping will only end when the partial pressure of the diffused air within the bladder is equal to the pressure of the air surrounding it. Diffusion pumping does not allow for controlled, on demand replenishing of pressure within the bladder to a predetermined pressure. Also, diffusion pumping does not allow the controlled diffusion of a preselected gas from an internal bladder chamber to an external bladder chamber at a predetermined rate. Similarly, diffusion pumping will not provide a substantially instantaneous increase in fluid pressure in response to the application of a heavy load. As a result, the pressure within conventional bladders cannot be altered in a short period of time, in response to a specific load or for customizing the bladder to the needs of the user.

Some prior art footwear use external inflation pumping devices to increase the pressure within their bladders. These devices typically include hand pumps or pressurized gas canisters connected to the bladder through channels extending within the footwear. Inflation pumping devices are used on a random basis, at preselected intervals or when a loss in pressure is perceived. If used at random or preselected times, the user can over pressurize the bladder and compromise its cushioning ability. Alternatively, if the user waits until a perceptible loss in pressure exists, he risks becoming injured as a result of using footwear with little or no effective cushioning.

Locating the gas source outside of the footwear makes instantaneous re-pressurization of the bladder during use impossible. In addition, prior art pumping devices do not instantaneously re-pressurize the bladder when a predetermined level of force is created within the bladder or after the bladder has been fatigued a predetermined amount. Instead, re-pressurization only occurs when the user chooses to operate the pumping device. Also, many external pressure devices lack a pressure gauge. As a result, it is difficult to control the final, effective pressure within the bladder when an external inflation pumping device is used.

In addition to the above drawbacks, an external inflation device is not a practical way of restoring pressure to a bladder when the footwear is being used. In order to replenish the pressure within a bladder, the wearer must stop his activity, locate the inflation pumping device, connect it to the bladder and begin pumping gas into the bladder chambers. Moreover, in order to use these devices, a wearer must carry the cumbersome inflation device with him during his run or activity. If the user does not carry the inflation device, he will not be able to restore pressure to the bladder as needed and could sacrifice cushioning and energy return if the bladder required replenishing.

It is an object of the present invention to provide a fluid containing bladder that overcomes the deficiencies of the prior art.

It is also an object of the present invention to provide a fluid containing bladder having a plurality of chambers with at least one of the chambers containing a reservoir of fluid for replenishing the other chambers. It is further an object to control the amount of fluid and the timing of its transfer from the reservoir chamber to the other chambers within the bladder.

BRIEF SUMMARY OF THE INVENTION

The present invention relates to a shock absorbing bladder for use in the sole of an article of footwear. The shock absorbing bladder includes a plurality of inflated chambers at different pressure levels. The bladder includes a first sealed chamber formed of a barrier material. The first chamber contains a fluid at a first fluid pressure. A second sealed chamber also forms part of the bladder. The second chamber is formed of a second barrier material and contains an inflation fluid at a second fluid pressure that is greater than said first fluid pressure. The second chamber is operatively coupled to the first chamber so that the inflation fluid from the second chamber moves into the first chamber as it leaves the second chamber. This results in an increase in fluid and fluid pressure within the first chamber.

The second chamber can also include a plurality of reservoir chambers that act as fluid reservoirs for restoring pressure and maintaining the cushioning capability of the surrounding chambers. The reservoir chambers can be formed of a barrier material that allows its contained gas to diffuse out into the surrounding chamber or chambers at a predetermined diffusion rate after the pressure in the surrounding chambers drops below a predetermined level. The reservoir chamber can also be formed of a barrier material that ruptures under the application of a predetermined load being applied to the reservoir chamber or as the result of fatigue of the chamber walls over a predetermined period of time or amount of use. The high pressure reservoir chambers may be positioned within the bladder so that they are not in the areas of highest impact during a foot strike.

The present invention provides a cushioning bladder having a reservoir system that maintains the cushioning pressure level within the bladder above a predetermined level in order

to reduce the risk of injury to the user. Additionally, the cushioning pressure level within the bladder can be re-established before the wearer notices the need and without the use of external tools. The fluid within the second chamber(s) is released into the first chamber in response to conditions occurring within the bladder.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is an exploded view of an article of footwear including a bladder according to a first embodiment of the present invention;

Fig. 2 is an exploded view of the bladder shown in Fig. 1;

Fig. 3 is a top perspective view of the bladder shown in Fig. 2;

Fig. 4 is a top perspective view of the bladder shown in Fig. 2 with a transparent outer surface;

Fig. 5 is a top plan view of the bladder shown in Fig. 2;

Fig. 6 is a cross section of the bladder shown in Fig. 5 taken along the line 6-6 of Fig. 5;

Fig. 7 is a perspective view of the reservoir chamber of the bladder shown in Fig. 2;

Fig. 8 is a cross section of a second embodiment of a bladder according to the present invention taken along the same line as line 6-6 of Fig. 5;

Fig. 9 is a perspective view of a third embodiment of a bladder according to the present invention;

Fig. 10 is an exploded view of the bladder shown in Fig. 9;

Fig. 11 is a top plan view of the bladder shown in Fig. 9;

Fig. 12 is a perspective view of the reservoir chamber of the bladder shown in Fig. 9;

Fig. 13 is a cross section of the bladder of Fig. 9 taken along the line 13-13 in Fig. 11;
Fig. 14 is a cross section of the bladder of Fig. 9 taken along the line 14-14 in Fig. 11;
Fig. 15 is a cross section of the bladder of Fig. 9 taken along the line 15-15 in Fig. 11;
Fig. 16 is a cross section of a bladder according to a fourth embodiment of the present invention taken along the same line as line 13-13 of Fig. 11;

Fig. 17 is a perspective view of a reservoir chamber with a valve and actuator;

Fig. 18 is a cross-section of a fifth embodiment of the present invention taken along the same line 6-6 of Fig. 6, incorporating gas-filled pellets;

Fig. 19 is an enlarged cross-section of a single pellet containing chamber in Fig. 18;

Fig. 20 is an enlarged cross-section of a single gas-filled pellet; and

Fig. 21 is an enlarged cross-section of a single, ruptured gas-filled pellet.

DETAILED DESCRIPTION OF THE INVENTION

The present invention relates to a shock absorbing bladder 10 for use in an article of footwear 1. The footwear includes an upper 2 for comfortably securing the footwear 1 about the foot of a wearer. Footwear 1 also includes a sole unit 3 having a midsole 4 into which bladder 10 is incorporated and a ground engaging outsole 5 covering at least a part of the lower portion of the midsole for providing traction.

As shown in Figs. 2 and 6, bladder 10 includes at least four sheets of the same or different barrier materials. Bladder 10 includes a first barrier sheet 11 extending coextensive with and secured to a second barrier sheet 12. Sheets 11 and 12 are secured to each other along their peripheral edges 34, 35, along a central area 21, and along a U-shaped area 23 using RF welding

and other well known securing techniques. In this manner, a reservoir chamber 14, including two U-shaped channels or chambers 13 are formed.

Bladder 10 also includes third and fourth barrier sheets 16, 17, respectively. Sheet 16 covers the first sheet 11, and sheet 17 covers second sheet 12. In a first embodiment, sheets 16 and 17 are welded directly to inner sheets 11, 12, respectively, along a U-shaped weld or connection area 19. Peripheral edges 36, 37 of sheets 16, 17 are also operatively secured to each other and to peripheral edges 34, 35 of sheets 11, 12 when inner sheets 11 and 12 are welded together. Alternatively, as shown in Fig. 8, peripheral edges 36, 37 of sheets 16 and 17 are spaced away from peripheral edges 34, 35. In this alternative embodiment, sheets 16 and 17 are secured directly to each other so that edges 36 and 37 move independent of edges 34, 35 to provide a more flexible bladder 10. As with sheets 11, 12, outer sheets 16 and 17 are operatively secured to each other and to sheets 11, 12, using well known techniques such as RF welding.

An outer fluid receiving, cushioning member 20 thus surrounds reservoir chamber 14 and provides the initial cushioning during a foot strike. Cushioning member 20 includes a first outer cushioning chamber 15 and a second outer cushioning chamber 18. Connection area 19 divides each chamber 15, 18 into a central chamber 25 and a U-shaped chamber 27. Each chamber 15, 18 is positioned on a respective side of chamber 14 and is formed when barrier sheets 16 and 17 are secured to barrier sheets 11 and 12. Because of the connection of the peripheral edges of sheets 11, 12, 16, and 17 to one another, chambers 15 and 18 are isolated from each other so that they are not in fluid communication. However, as shown in Fig. 8, chambers 15 and 18 can be formed by directly securing peripheral edges 36 and 37 to each other so that they are spaced away

from peripheral edges 34 and 35. In this alternative embodiment, chambers 15 and 18 are in fluid communication with each other and their shared fluids surround inner reservoir chamber 14.

Outer chambers 15 and 18 include a gaseous cushioning fluid, for example, hexafluorethane, sulfur hexafluoride ("supergas"), or one of the other suitable gases which are identified in U.S. Patent Nos. 4,183,156, 4,219,945, 4,936,029, and 5,042,176 to Marion F. Rudy, incorporated herein by reference. Bladder chambers 15 and 18 can also be inflated with air, nitrogen, or other gases for example in the manner set forth in the '029 Rudy patent, U.S. Patent No. 5,713,141 to Mitchell et al, and U.S. Patent Nos. 6,082,025 and 6,013,346 to Bonk et al. Chambers 15 and 18 are inflated to a predetermined pressure such as 5, 15 or 25 PSI for providing a desired cushioning affect to a specific portion of the footwear. Chambers 15 and 18 can be inflated to the same or different pressures depending on the type and amount of cushioning needed in the portion of the footwear where bladder 10 is positioned. Adjacent channels 25 and 27 of the same chamber 15 or 18 can also be inflated to different pressures, provided provision is made to divide the channels into two separate channels that are not in fluid communication with each other.

The material forming barrier sheets 16 and 17 may be, for example, a film formed of alternating layers of thermoplastic polyurethane and ethylene-vinyl alcohol copolymer, as disclosed in U.S. Patent Nos. 5,713,141 and 5,952,065 to Mitchell et al., incorporated by reference. A variation upon this material wherein the center layer is formed of ethylene-vinyl alcohol copolymer; the two layers adjacent to the center layer are formed of thermoplastic polyurethane; and the outer layers are formed of a regrind material of thermoplastic polyurethane and ethylene-vinyl alcohol copolymer may also be utilized for the barrier sheets. Another

restoring gas and pressure to the outer chambers 15, 18 so that the cushioning properties of bladder 10 are not compromised during the life of the footwear, and it provides an additional layer of cushioning that prevents bladder 10 from bottoming out when heavy loads are applied.

The inner cushioning chamber 14 is formed when sheets 11 and 12 are welded together, as discussed above. As illustrated in the figures, chamber 14 includes fluid channels 13 that are formed in chamber 14 by welding sheets 11 and 12 together at points spaced inwardly from peripheral edges 34, 35. While channels 13 are illustrated isolated from one another, they can be in fluid communication. Channels 13 are inflated to a higher pressure than chambers 15 and 18 so that diffusion only occurs in one direction, from chamber 14 into chambers 15, 18. Because chamber 14 acts as a gas reservoir for chambers 15 and 18, the gas contained within channels 13 moves into chambers 15 and 18 to restore or maintain the originally established pressure levels for cushioning a foot strike. Chamber 14 typically contains nitrogen at a pressure between 40 and 60 PSI, with a preferred range being between 45 and 50 PSI when sheets 11 and 12 are formed from urethane based materials. However, higher pressures can be used depending on the barrier materials chosen for sheets 11 and 12. It is contemplated that one of the supergases discussed above could be used in place of nitrogen.

The materials forming inner sheets 11, 12 allow the gas contained within inner chamber 14 to move into outer chambers 15, 18 in response to certain preselected conditions. These conditions include the gradual loss of pressure over time, the application of a predetermined load and the use of the bladder for a predetermined period of time. The materials are selected, in part, based on their Gas Transmission Rate (GTR). The GTR reflects the amount of gas that diffuses through a barrier material having a specific thickness over a specific period of

time. GTR is a constant that varies with the thickness of the material. The GTR changes as the thickness of the material changes. Because the desired pressure level in chambers 15 and 18 can differ, the GTR of sheets 11 and 12 can also differ.

In a preferred embodiment, sheets 11 and 12 are chosen so that their GTR allows the gas from channels 13 to diffuse into chambers 15 and 18 at the same rate or substantially the same rate as the gases diffuse out of chambers 15 and 18. One preferred combination of materials and gases would use a standard urethane film for sheets 16 and 17 forming outer chambers 15 and 18, with outer chambers 15 and 18 containing nitrogen at 15 PSI; and an EVOH material for sheets 11 and 12 forming inner reservoir chambers 14, with nitrogen at 50 PSI being contained in chambers 14. As a result, the gas from channels 13 diffuses into chambers 15 and 18 until the pressure within all the chambers 14, 15 and 18 is equal to or has reached a predetermined level. Routine testing can be done with the barrier materials and gases to arrive at an appropriate diffusion from channels 13 into chambers 15 and 18. The reservoir function of inner chamber 14 can extend the life of bladder 10 as an effective cushioning element for a significant period of time, as much as two or more years, when compared to a conventional cushioning bladder.

In another embodiment of the present invention, the cushioning pressure is restored within chambers 15 and 18 when chamber 14 fails. This is accomplished by forming chamber 14 with sheets 11, 12 that fail when a load applied to bladder 10 causes a predetermined internal pressure within chamber 14. When the predetermined pressure level within chamber 14 is reached, sheets 11 and 12 will fail and the fluid within chamber 14 will enter chambers 15 and 18 to restore the original level of cushioning pressure, which can be in the range of 5 to 25 psi, preferably 15 psi, or establish a new level of cushioning pressure within chambers 15 and 18, up

to as high as 50 psi. Sheets 11 and 12 can include a preformed material weakness or they can be formed of a material that is more brittle than sheets 16 and 17. After sheets 11 and 12 fail, the newly established pressure levels within chambers 15 and 18 can be greater than the original pressure levels. In this embodiment, the materials used for sheets 11 and 12 would include thin material with low elasticity. It is preferred that the material allow no outward diffusion of the contained gas prior to its rupture, or at least that the material have a low rate of diffusion. Thin and elastic material is not preferred, since such material would allow the inner chamber to grow under high pressure. As with the above discussed embodiment, the gas contained within channels 13 is preferably nitrogen and the gas in chambers 15 and 18 is preferably nitrogen, but can be air or a supergas.

In another fatigue related embodiment, sheets 11 and 12 are formed of a material that fails after being used for a predetermined period of time. For instance, these sheets may be formed of a material that fails after the bladder has been flexed one hundred thousand (100,000) times or after three (3) months of use. In this embodiment, sheets 11 and 12 are thinner and more brittle than sheets 16 and 17. One preferred material would be Saran (PVDC). In general, the material should have less elasticity and less flex resistance, and have a high crystalline content. Failure can also be built into the inner chamber through the use of weak welds. As with the previous embodiment, the gas within chamber 14 is transferred to chambers 15 and 18 when sheets 11 and 12 fail in order to increase the pressure within these chambers and restore their ability to cushion during a foot strike.

The fluid contained within chamber 14 can also be released into chambers 15 and 18 by manual activation. As seen in Fig. 17, one way valves 60 can be positioned within each

channel 13 of chamber 14 for allowing fluid to flow from chamber 14 into chambers 15 and 18.

An actuator 61 is positioned on an exterior surface of footwear 1 for opening and closing each valve 60 so that a controlled amount of fluid is transferred from chamber 14 to chambers 15 and 18. Actuator 61 can release only a portion of the fluid within chamber 14 at a given time.

Alternatively, actuator 61 can include a sharp end that punctures chamber 14 in multiple locations so the fluid within chamber 14 is released into chambers 15 and 18. Any conventional valve can be used for valves 60, with suitable values disclosed in U.S. Patent No. 5,253,435 to Auger et al., which is incorporated by reference.

Another embodiment according to the present invention is shown in FIGS. 9-15. As shown in FIG. 9, a bladder 100 can be formed to extend along the length of a midsole. Full length bladder 100 includes four barrier sheets 111, 112, 116, 117. First barrier sheet 111 and second barrier sheet 112 are secured together along their peripheral edges 134, 135, respectively, as discussed above with respect to sheets 11 and 12. As discussed above with respect to sheets 16 and 17, sheets 116 and 117 cover sheets 111 and 112, respectively, when bladder 100 is assembled. The peripheral edge 136 of sheet 116 is secured to sheet 111 and the peripheral edge 137 of sheet 117 is secured to sheet 112 using well known techniques as previously discussed. In an alternative embodiment, peripheral edges 136 and 137 are secured to each other and peripheral edges 134 and 135 are spaced inwardly therefrom for increasing the flexibility of bladder 100 by eliminating the need for peripheral edges 134 and 135 to move each time peripheral edges 136 and 137 move.

A fluid chamber 114 having multiple fluid channels 130-133 is formed when inner sheets 111 and 112 are secured together along their peripheral edges 134, 135 and at

locations 145 spaced inwardly from these edges. Channels 130-133 are positioned throughout full length bladder 100 for providing cushioning to the entire foot. An outer cushioning member 120 is formed around inner chamber 114, and includes two non-communicating chambers 122 and 123, each located on one side of inner chamber 114. As with member 20, member 120 provides cushioning during a foot strike. Chambers 122 and 123 are separated by the peripheral edge welds that secure sheets 111, 112, 116, 117 together. Alternatively, when sheets 116 and 117 are directly secured together, and peripheral edges 134, 135 of inner sheets 111 and 112 are positioned inwardly from the peripheral edges 136, 137, chambers 122 and 123 are in fluid communication with each other and their shared cushioning fluid surrounds inner chamber 114.

Inner channels 130-133 are inflated with a gas such as those discussed above with respect to chamber 14. In a preferred embodiment, the gas is nitrogen and the chambers are inflated to a pressure between 40 and 60 PSI, with a preferred pressure being about 50 PSI. Like channels 13, inner channels 130-133 perform a dual function, they provide a second layer of cushioning and act as a reservoir for replenishing the fluid pressure within chambers 122 and 123. Each channel 130-133 is inflated using a respective inflation port 141-144 in an inflation region 140.

The ports 141-144 are positioned so that they can each be individually sealed in weld region 146 after their respective channel has been inflated. Alternatively, more than one port can be sealed with a single weld. U.S. Patent No. 5,832,630 to Potter, incorporated herein by reference, discloses a method of making a bladder using plural inflation ports. Inner channel 130 extends from inflation region 140 toward the rear of bladder 100. Channel 130 has its largest volume in the center of the heel region. Inner channel 131 extends in both the forefoot and heel

regions of bladder 100 to replenish the fluid pressure and provide additional cushioning within both regions. In the forefoot, channel 131 extends along the lateral edge of bladder 100. In the heel, channel 131 follows the outline of a portion of channel 130 and extends along the medial and lateral sides of bladder 100.

Channel 132 creates a forefoot cushioning region surrounding the ball of the foot and in the area where toe-off occurs. As with channel 131, channel 132 can be provided with additional or extended welds 155 where it is desirable not to have a high pressure fluid channel, such as in area 141, to prevent the user from experiencing discomfort due to its high pressure and related lack of flexibility. A majority of channel 133 extends in the medial/lateral direction in the forward portion of the midfoot.

As discussed above with respect to bladder 10, sheets 111 and 112 are formed of a material and of a thickness that exhibits a suitable GTR which allows gas to diffuse from channels 130-133 into chambers 122 and 123 to counteract the diffusion that occurs through sheets 116 and 117. By allowing gas, such as nitrogen, to diffuse from channels 130-133, a predetermined level of pressure can be maintained or re-established in chambers 122 and 123, as discussed above with respect to chambers 15 and 18 of bladder 10. Alternatively, sheets 111 and 112 are formed of a material that will fail in response to an applied load or after a predetermined period of use. This creates instantaneous re-pressurization of chambers 122 and 123 in response to a predetermined occurrence, as discussed above with respect to sheets 11 and 12 of bladder 10.

As illustrated in Figs. 18 to 21, each of the above discussed embodiments can also include one or more gas filled members 200 for replenishing the pressure level within any chamber. For example, members 200 can be included in reservoir chamber 14 or 114 for

replenishing their pressure after the nitrogen has diffused out into the surrounding chambers.

Alternatively, members 200 can be located within chambers 15, 18, 122 and 123 for supplementing the re-pressurization provided by chambers 14 and 114. Gas filled members, or pellets, 200 have a very high internal pressure, relative to the pressure levels in chambers 15 and 18, that is released when their barrier sheets are ruptured. The pressure can be on the order of 80 to 120 PSI, with a preferred pressure being between 95 and 105 PSI. The volume and internal pressure of pellets 200 are chosen based on the volume of the chamber in which they are enclosed and the desired resulting pressure therein after pellet 200 ruptures. Pellets are formed of materials such as aluminum, hard plastics, MYLAR, or PVDC (Saran), that resist rupturing during normal foot strikes when chambers 15 and 18 are at the desired pressure. Instead, only an excessively high amount of force directly applied to pellet 200 will rupture it. This occurs when the pressure in outer chambers 15 and 18 become low enough for the force of foot impact to cause chamber 13 to be compressed sufficiently to rupture pellets 200.

Numerous characteristics, advantages and embodiments of the invention have been described in detail in the foregoing description with reference to the accompanying drawings. However, the disclosure is illustrative only and the invention is not limited to the illustrated embodiments. Various changes and modifications may be effected therein by one skilled in the art without departing from the scope or spirit of the invention.